Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

THE AMERICAN TOAD (BUFO LENTIGINOSUS AMERICANUS, LeCONTE). II

A Study in Dynamic Biology

NEWTON MILLER

Clark University

Hibernation

Little is known about the toad during the winter. An anonymous article in *Cornhill* states that toads go down in the mud by ponds and become encysted in balls of clay. Allen is of the same opinion. More recently Gage says he thinks they go into the ground for hibernation and not under boards, stones, etc., as supposed. Toads were found under leaves in March, 1895, by Kirkland, who also states that they "do not hibernate singly, as a rule and it is not an uncommon thing to find in winter or spring a dozen or more closely packed together under a rock, board or in some other sheltered spot." Various individuals tell me that they have ploughed up toads in the fields or dug them up in gardens or flower beds in the spring. There is little doubt that in this latitude they normally pass the winter in the ground.

Toads bury themselves for the winter or often for the day in loose earth. To do this they always go down backwards. With a forward lateral movement of the hind feet the earth is pushed out and to either side and the body forced into the hole by the front legs. The loose earth falls over the head as the toad descends, thereby filling the burrow. In this way little trace is left to tell of the whereabouts of the toad.

It is probable that those found under leaves, etc., in early spring had emerged from winter quarters during a warm spell and had taken temporary refuge in such places.

Experiment No. I.

An experiment on hibernation was begun October 8. Holes twenty-eight inches deep were dug in three different localities. Into each hole was placed the four sides of a 14 x 36 x 36 inch cage made of $\frac{1}{4}$-inch-mesh wire netting. Then the holes and cages were filled to the level of the ground. Twenty toads were placed in each cage and a wire covering sewed on, thus making an enclosure without bottom, filled with soft earth and with a free space of eight inches between the ground and the top.

Cage *A* was placed on an exposed north slope of a hill beneath two pines. The slope at this point was probably 20°, therefore no water stood in or about the cage. The ground here is at least two thirds sand and gravel. Little protection was furnished by the pines, since their lowest branches were twelve to fifteen feet above the ground.

Cage *B* was located in a dry, well-sheltered place under the drooping branches of some spruces on a hill-side facing the east. So well was it protected that the sun never reached it and very little rain or snow. The ground at this point is a sandy clay.

Cage *C* was sunk under a maple tree in a place not more than four feet above the water in a near-by pond. No protection was furnished by the maple. Ashes, sand and loam in about equal parts composed the soil at this place.

The toads for this experiment were collected from the fourth to eighth of October. Each was weighed and marked by cutting off a toe. Those in *A* were put out the eighth of October and those in *B* and *C* the following day. One to several toads were found out of the earth in one or all the cages until November 26 with the exception of the twenty-ninth of October. My notes show a very slight tendency for those in cage *A* to hibernate before those of *B* and *C*.

After the twenty-sixth of November nothing was seen of the toads until the twenty-eighth of March, when *A* was dug up, and eleven days later cage *C*. Fourteen were found in *A*, of which only three were alive. The depths at which they were found varied from one to twenty-four and a half inches. All above sixteen inches (the depth to which the ground was frozen) were dead. In *C* thirteen were found, of which nine were alive. There had been a trench dug near one end of the cage in the fall and the earth in this end was frozen to a depth of twelve inches. Two toads near the surface and two in the frozen end, one at a depth of twelve inches, were dead. Those alive were down below the frost line, which in this place was between eight and nine inches.

The accompanying table shows the weight of each live toad at the time it was put out and when dug up, also the depth at which it was found.

Cage C

No. of Each Toad.	Weight, October 9.	Weight, April 4.	Depth in Inches.
1	50.5	44.0	15
3	19.5	15.0	9½
4	24.0	18.8	12½
5	27.0	25.6	14½
7	32.5	26.6	20
8	27.0	23.9	10
10	24.5	21.2	16½
12	5.5	4.6	11
19	19.5	15.8	15

Cage A

No. of Each Toad.	Weight, October 9.	Weight, March 29.	Depth in Inches.
10	16.5	12.9	17½
13	9.5	7.0	17½
19	20.5	15.0	24½

Average loss of weight 3.8 grams.

The total loss of weight was 15.3 per cent. of total weight.

B was not disturbed, and the first toad to appear was no. 1 on the thirtieth of April, and the second and last was no. 7 on the twenty-eighth of May.

Experiment II

Another experiment was made on two toads which were placed in a 7 x 7 x 7 inch wooden box that contained some four inches of rather dry clay. A stone was laid on top and the box sunk ten inches in the side of a bank composed of clay and gravel. On the first of March, when the box was dug up, the ground all about it was frozen so hard that it had to be dug out with a pick. The earth in the box had been moist enough to freeze into clods, which were easily broken with the fingers. Both toads were alive, but no. 2 died two days later without showing any other signs of life than the beating of its heart. No. 1 moved her legs feebly as soon as broken out of the clay, had her eyes open in less than five minutes and within ten minutes more she was crawling about on the snow. Only the tips of some of her toes seemed to be frozen, but these never became sore. No. 2, as far as I could detect, was not frozen more than no. 1. No. 1 began feeding on the second day and during the remainder of the winter showed no signs of hibernating.

Experiment No. III

For this experiment a 12 x 12 x 24 inch glass aquarium was used in which was placed about three inches of moist earth. Six toads properly labeled were put in the cage, which was kept within eight inches of my radiator. As I was in my room most of the day and slept there at night I could watch them closely. I had a supply of meal worms, and every time a toad appeared it was given all it would eat. They came up usually about 8:30 P.M. and buried themselves by 10:00 P.M. Frequently they shed their skins and went down at once. No. 4 had the habit of only half burying herself and, probably, one fourth of the time was spent thus, but during this time she was rarely found sleeping.

The weight and sex of each toad was as follows:

No. 1,	♀	8.8 grams.
No. 2,	♀	27.8 grams.
No. 3,	♂	22.2 grams.
No. 4,	♀	76.5 grams.
No. 5,	♀	6.5 grams.
No. 6,[7]	♂	39.0 grams.

These toads were under daily observation from October 23 to April 1, excepting five days from December 26 to 30. Fig. 7 is given as an average month's record of this experiment. The continuous lines represent the time the toads spent under the earth; the breaks, the number of times the toads came up out of the earth; the figures in the breaks, the number of meal worms eaten at such times.

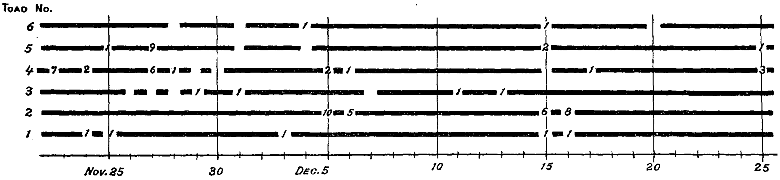

FIG. 7. Record of six toads for one month.

Experiment No. IV

This experiment was also carried on in my room, from the twenty-third of October until the eighth of April. During this time a female, weighing forty-eight grams, was kept in a small bell jar which contained, besides the toad, only a small thin piece of sponge. The sponge was kept moist and a piece of glass over the top of the jar prevented too rapid evaporation.

When the toad was placed in the jar she was cold, numb and to all appearances hibernating, but five hours after being brought into a warm room she was wide awake, and from then on to the end of the experiment was never seen with her eyes closed nor showing the least signs of hibernation. She fed throughout the winter, eating in all, the small number of 173 meal worms or their equivalent, but at no time did she go longer than nine days without feeding. Eight worms were the most she ever ate at one time, while one to three constituted her usual meal. She refused food during the day and fed only from 7 to 10 P.M.

---

[7] At the end of the experiment nos. 2, 5, 6 had increased their weight, respectively 7.4, 4 and 0.49 grams.

Experiment No. V

This experiment is a duplicate of no. IV. with the exception that two small toads (about 8 grams) were used. The experiment began on the twenty-third of October and continued until the death of the toads, which, for the male, occurred December 15 and for the female, February 10. The female fed throughout this time with the exception of two periods, November 7–17 and December 18–February 10. During these two intervals she at times appeared to be hibernating or simply sleeping. It was almost a month before the male began feeding, but afterwards fed until he died. At no period did he show any tendency to hibernate. The male escaped from the cage and was found dried up. The female refused food from December 18 to February 10, became emaciated and died as though starved.

Conclusions

From experiment no. I, it is seen that toads go down into the ground to hibernate and that all of those not below the frost line in unsheltered places, perish.

Experiment no. II shows that toads in protected places can resist freezing temperature.

It is a question whether toads make any preparation at all for the winter more than simply burying deeper than they are accustomed to do in the summer. Experiment no. I shows that some had not hibernated as late as November 26. Toads are active until it becomes too cold for them to capture insects; as a cold wave comes, the toads for the first time begin to prepare for winter by digging a little deeper. As the ground gets colder, they go further down, keeping a little below the frost line. I have found no evidence that toads select places in the fall and then proceed to bury themselves at once to a depth of eighteen to twenty-four inches.

Toads kept in a warm room do not have periods of torpidity. Boulenger says that batrachians never go into complete lethargy. The one in experiment no. IV was never asleep and those in experiment no. III were always wide awake and active when dug up. None of them became sluggish. The female of experiment V was, at times, during two periods seen with her eyes closed, but at these times she was easily awakened by a slight touch or a jar of the cage. At no time did she appear to be more than napping. All of the toads kept in my room fed throughout the winter, although eating only a small quantity. The period of least activity was from January 19 to February 19, when only one fed. Three of these toads fed eagerly during April, May and June.

There is no evidence that toads seal up their eyes, mouth and nostrils as a preparation for hibernation. Winter to the toad is only a long day, a suspension of work, a sleep. He is ready to begin his daily routine as soon as warmed up even in midwinter.

ENEMIES OF THE TOAD

When we consider the number of eggs laid and find that the number of toads does not increase, we are led to ask the question, What are the forces that keep the species in check? If we take the low figure of eight thousand eggs for an average spawn, then all of these—as well as all the eggs of the other spawns of a single female—or the toads that develop from them, except two, must meet a premature death in order that the species may just hold its own. This seems to be what is taking place with the toad.

What happens to this multiple of eight thousand eggs is partially known. There is no period from the laying of the egg until death by old age that the egg, larva or toad is not subject to attack. I have found little evidence of the eggs being eaten in the ponds. Crayfish confined in the laboratory ate a few. Saprolegnnia destroy a small per cent. of the eggs, not by attacking the fertile ones directly, but by spreading from those that are decaying. The gelatinous sheath which envelops the delicate eggs is almost a perfect protection, but, as soon as the tadpoles wriggle out of it, they are preyed upon by fish, newts, crayfish, insects, and especially the predaceous aquatic larvæ of insects.

I give the results of my feeding tests to show how destructive some of the enemies of the tadpoles are.

Species.	No.	Time.	No. Killed.	Rate per Day.
1. Dragonfly nymph, Libellula sp.?	4	May 24–June 24.	500	4
2. Dragonfly nymph, sp.?	1	June 21–June 28.	37	4.5
3. Water beetle, Acilius sp.?	1	June 21–June 30.	40	4
4. Giant w. beetle, Dytiscus sp.?	4	May 9–June 23.	4,800	26.6
5. Water tiger, Dytiscus larva.	1	June 13–June 33.	425	42.5
6. Giant w. bug, *Belostome americanum.*	1	May 24–June 26.	360	11.2
7. Newts, *Diemictylus viridensens.*	4	May 8–June 19.	1,485	9
8. Crayfish, *Cambarus bartoni.*	1	June 1–June 24.	200	8.6
9. Leopard frog larva, *Rana pipiens.*	1	July 9–July 14.	66	8.8
10. Pickerel, Esox sp.? (four inches long).	1	June 22–June 24.	80	26.6

The above tests, with the exception of nos. 2 and 9, were made with tadpoles which were hatched from eggs laid about April 28. Since the transformation of the larvæ of this early laying began the twenty-second of June, it is seen that a portion of these tests were made with tadpoles almost ready to abandon the water. Those for no. 9 hatched on the twenty-fifth of June. No. 2 was fed for the first five days on tadpoles of the early spawn and the rest of the time on those hatched June 25. Only one tadpole a day was destroyed by this nymph during the first five days.

In treating the above data it must be taken into consideration that these tests were made in the laboratory and that tadpoles constituted the whole of the food of these animals during the tests. This is a very abnormal condition compared with that found in nature.

Two toads just metamorphosed were found in the stomach of a green frog about a week old. Mr. E. H. Eaton tells me of finding a toad an inch long in the stomach of a leopard frog. Adult toads could not be induced to eat the young. They would take them up, but immediately reject them.

The drying up of ponds during May and June kills great numbers of the tadpoles. More than 90 per cent. of the spawn is laid in the early spring when the ponds are full. The tadpoles migrate to the shallower water, where they find food and warmth. Here they crowd into small pockets, and as the water lowers are left in the isolated puddles to perish, unless timely rains refill the pond. The "drying-up process" is disastrous not only to the larvæ, but also to the toads. Great numbers just emerged are no doubt dried up before they find damp sheltered retreats. Adults also soon perish if deprived of moist places. I give the following to show the rapidity with which transpiration and absorption of water may take place in toads. A toad weighing 4.4 grams when placed in water, weighed 5.5 grams fifty-five minutes later. One hour later, after having been kept at a temperature of 85° F. in a box made of blotting paper, it weighed 4.8 grams. Another toad treated as above weighed 3.8, 4.5 and 3.8 grams, respectively. A third weighed 39.8 grams when placed in one fourth inch of water and 49.9 grams three hours later. This is a gain of 25 per cent of her first weight. This toad was capable of reducing her weight 8.7 grams by ejecting water. From these experiments it is seen how important moisture is to the toad and why toads seek damp places.

Birds play no small rôle in the destruction of the toad. Of the domestic varieties ducks, chickens and guinea fowls are always mentioned and to these Kirkland adds geese as feeding on toads, especially the young just as they are emerging.

''Crows, grackles and several species of ducks and herons,'' writes A. K. Fisher, of the Biological Survey, ''are known to feed on small frogs and tadpoles, and undoubtedly do not discriminate in favor of toads.'' He presents further evidence to prove that the screech owl must be considered as a destroyer of toads. By stomach examinations of a number of crows, W. B. Burrows finds that the toad is a common article of food. Young partridges were tested on this point. They eagerly picked up the little toads, thereby killing them, but usually refused to eat them. Miss M. Morse reports the quail as feeding on young toads. As for predatory birds, the toad is an agreeable morsel of food. Mr. Fisher writes me that he has observed the broad-winged hawk feeding on toads while the latter were spawning. He also found '' five stomachs of the red-tailed hawk, eight of the red-shouldered hawk, and five of the broad-winged hawk which contained the remains of toads.'' From the observations of Mr. F. H. Mosher, he states that ''the marsh hawk is one of the worst enemies of the toad, destroying large numbers of them during the spawning season.'' He also states on the same authority that a toad was found in the nest of a Cooper's hawk.

Skunks and raccoons are the only mammals reported as feeding upon toads. Mr. E. H. Short writes that in his locality skunks destroy great numbers in the late fall, and that he found in October, 1904, the remains of seven toads which had been killed in one night (by a skunk?). His evidence on this point does not seem conclusive. Concerning raccoons, Dr. H. B. Davis occasionally feeds toads to those he has in confinement.

Professor Surface records twenty-seven species and varieties of serpents from Pennsylvania, of which ten feed on toads, and two others are suspected. The feeding habits of some of these have not yet been determined and it may be found that part of them use the toad as food. Toads constitute 41½, 20, 16 and 15 per cent. of the food, respectively, of the spreading adder

(*H. platirhinas*), the striped water snake (*R. leberis*), the common garter snake (*T. sirtalis*), and the spotted water snake (*N. sipedon*). The common garter snake and the spotted water snake are reported also as feeding on tadpoles.

Some of the game fish feed upon frogs and, presumably, they take toads also. Perhaps many toads are thus destroyed during the spawning season. We have reason to think that fishes feeding on insects and small fish devour tadpoles also. In pond no. 4 eggs were laid by the thousands and a large per cent. of them hatched, but not a single toad emerged. By the twenty-fourth of May not more than 200 tadpoles of the first laying remained and a few days later not one was to be found. There are fishes and crayfishes in this pond and the probabilities are that they destroyed the tadpoles.

Boys are very destructive to toads in the spawning season. This spring no less than one hundred and ten toads were killed about ponds nos. 1, 3 and 4. In 1897 Dr. Hodge records as one day's count two hundred dead about pond no. 4, and also that two boys had killed and carried away 300 from the same pond the day before.

Judging from my experiments, many toads die during the winter. As stated in the chapter on hibernation, sixty toads varying in size from 2 to 55 grams were put out in cages in the fall. Neglecting those under five grams (which I have reason to think escaped before cold weather) there were left fifty-one, of which only fourteen came out alive in the spring. This is a loss of 72.5 per cent., which surely must be above normal. However, further experiments and observations lead me to think that toads are killed if completely frozen. January 30, I permitted a toad 6.5 cm. long to bury itself in a cage containing a mixture of moist clay and loam. The cage was then subjected to a temperature of — 10° F. for twenty-four hours. At the end of this time the toad was frozen solid, and when thawed out showed no signs of life.

Another experiment, begun December 28, temperature 54° F., was made on five toads ranging between 3 and 7.5 cm. in length. These toads were put in a wire cage filled with leaves and then buried in leaves, which had drifted into an angle of a building. March 13, the cage was examined and all the toads found dead. These toads during this time had been subjected to several days of 0° F., weather.

On March 28 I examined a drift of leaves. Two dead toads were discovered half buried in the ground beneath leaves. There were about eight inches of leaves over them.

Contrary to these observations are those Kirkland, which might lead one to infer that toads can pass the winter successfully under leaves in this region. But as Mr. Kirkland's observations were made in March, and as toads in favorable springs emerge from their winter quarters in this month, we are inclined to believe that those he found under leaves had previously come out of hibernation and had taken temporary refuge where he found them.

The sewers of a town constitute a most destructive trap for toads. Sewer cleaners tell me that they take out "piles of toads" especially in the fall and spring. Examination of the "man holes" in May shows that there are on an average four toads in each one. At this rate, for Worcester alone, there are no less than 24,000 toads thus caught, which probably means their death also. It is making a low estimate to say that 50,000 toads perish annually in the sewers of Worcester. It is very probable that more adult toads in a city are killed by this means, alone, than by all others combined.

I give the following table as a rough estimate of the part that each known factor plays in holding the species in check.

Percentage of destruction until time of metamorphosis caused by:

Non-fertile eggs	15 per cent.
Drying up of ponds	25 per cent.
Insects, newts, fish, etc.	39 per cent.
Fungi	1 per cent.
Disease	5 per cent.
Total	85 per cent.

The remaining 15 per cent. may meet the following fate:

Drying up	20 per cent. =	3 per 100 eggs.
Domestic fowls and other birds	10 per cent. =	1.5 per 100 eggs.
Reptiles	6 per cent. =	.9 per 100 eggs.
Boys	2 per cent. =	.3 per 100 eggs.
Sewers, wells, etc.	15 per cent. =	2.25 per 100 eggs.
Mechanical means	10 per cent. =	1.5 per 100 eggs.
Winter	25 per cent. =	3.75 per 100 eggs.
Disease	3 per cent. =	.45 per 100 eggs.
Miscellaneous (*including old age*)	9 per cent. =	1.25 per 100 eggs.
Total	100 per cent. =	15 per 100 eggs.

SUMMARY

B. l. americanus spawns from the latter part of April to the first of July.

This species lays in small ponds and only a portion of each is used as a spawning ground.

The males are the first to reach the water in the spring.

88.8 per cent. of all the toads in a pond at any given time are males. Males are in proportion to females as 80.7 : 100.

Trilling in the full vigorous voice is heard only during the mating season.

Females respond to the call of the males.

Males will not hold other males.

Spawn may be deposited at a depth of eighteen inches or more. This depth does not affect materially the hatching.

Fertilization takes place in an improvised basket formed by the hind feet of the male and the body and hind legs of the female.

85 per cent. of the eggs laid in natural ponds are fertile.

Oviposition requires six to eighteen hours.

The laying of two or four strands of eggs at a time can not be considered of specific importance.

Toads lay 3,900 to 15,800 eggs at one laying.

The eggs hatch in two to six days, depending upon the temperature.

Metamorphosis takes place in thirty-two to two hundred days.

On an average the tadpoles double their weight seven times in thirty-two days.

The tadpoles are omnivorous.

Toads feed entirely on animal matter. No food is taken unless it shows signs of life.

Toads refuse no insects, worms or slugs which they can swallow.

On an average toads feed only once in a day and a half.

The average amount eaten in a day by a toad is 1.12 grams.

About 80 per cent. of the toad's food consists of harmful insects.

Toads may be active from the latter part of March to the middle of November.

Toads are chiefly nocturnal.

Toads go into the ground to pass the winter.

The greater per cent. of those that do not get below the frost-line perish.

In the strictest sense of the term, toads do not hibernate if kept in a warm place.

Toads feed throughout the winter if kept warm, although eating comparatively little.

No preparation is made for the winter other than burying to a depth below the frost line.

Some toads do not hibernate until after the middle of November.

The eggs are seldom eaten by other animals.

Great numbers of tadpoles are destroyed by insects and insect larvæ.

Birds, fishes and reptiles feed upon tadpoles.

A large per cent. of the eggs and larvæ are killed by the lowering of the water.

Toads are destroyed, chiefly, by all classes of vertebrates; by drouth and winter, and by the sewer systems of towns.

Literature

1876. American Encyclopedia, Vol. XV, pp. 777–9.

1899. Allen, G. M. Notes on the Reptiles and Batrachians of Intervale, New Hampshire. *Proc. Bost. Soc. Nat. Hist.*, Vol. XXIX, pp. 63–75.

1865. Allen, J. A. Catalogue of the Reptiles and Batrachians of Massachusetts. *Proc. Bost. Soc. Nat. Hist.*, Vol. XII.

1895. Assheton, R. Notes on the Ciliation of Ectoderm of Amphibian Embryo. Vol. XXXVIII, p. 465.

1892. Beddard, F. E. Animal Coloration. London, p. 159.

1894. Bos, J. R. Amphibia, Agriculture, Zoology, pp. 79–81.

1897. Boulenger, G. A. The Tailless Batrachians of Europe, Vol. I, pp. 23–67; Vol. II, pp. 221 ff.

1892. Boulenger, G. A. Poisonous Secretions of Batrachians. *Nat. Sci.*, Vol. I, pp. 185–190.

1896. Brimley, C. S. Batrachians found at Raleigh, North Carolina. Amer. Nat., Vol. XXX, p. 500.

1886. Brocchii, P. Crapud. Traité de Zoologie Agricole, pp. 240–242.

1833. Buckland, W. On the Vitality of Toads Enclosed in Stone and Wood. *Amer. Jour. Sci.*, Vol. XXIII, pp. 272–277.

1901. Conradi, A. F. Toads Killed by Squash Bugs. *Science*, Vol. XIV, p. 816.

1884. Cope, E. D. Batrachians of the Permian Period of North America. Amer. Nat., Vol. XVIII, pp. 26–29.

1896. Cope, E. D. The Geographical Distribution of Batrachians and Reptiles in North America. Amer. Nat., XXX, pp. 886–902 and 1003–1026.

1889. Cope, E. D. Batrachians of North America. Bull. U. S. Nat. Mus., No. XXXIV, pp. 277–281.

1907. Courtis, D. A. Response of Toads to Sound Stimuli. Amer. Nat., Vol. XLI, pp. 677–682.

1886. de Fischer, J. Rôle des Amphibians en Agriculture.

1906. Dickerson, M. C. Bufo lentiginosus americanus. The Frog Book, pp. 63–88.

1905. Ditmars, R. L. Batrachians of the Vicinity of New York City. *Amer. Mus. Jour.*, Vol. IV, pp. 186–190.

1898. Gage, S. H. The Life History of the Toad. College of Agriculture, Cornell University.

1898. Gage, S. H. Hibernation, Transformation and Growth of the Common Toad (*B. l. americanus*). *Proc. Amer. Ass. Adv. Sci.*, XLVII, pp. 374–375.

1901. Garman, H. The Food of the Toad. Ky. Agri. Exper. Station Bull., No. 91, pp. 62–68.

1902. Garman, H. Synopsis of the Reptiles and Amphibians of Illinois. Bull. Ill. State Lab. Nat. Hist., III, pp. 335–339.

1906. Hartman, F. A. Food Habits of Kansas Lizards and Batrachians. *Tr. Kansas Acad. Sci.*, XX, pt. 2.

1903. Hay, W. P. On Batrachians and Reptiles. *Forest and Stream,* LX, pp. 425–6.

1882. Hinckley, M. H. Mouth Structures of Tadpoles of Anurous Batrachian. *Proc. Bost. Soc. Nat. Hist.,* XXI, pp. 307–314.

1898. Hodge, C. F. The Common Toad. *Nature Study Leaflet,* Worcester, Mass.

1875. Huxley, T. H. Amphibia. Encyclopedia Britannica, 9th ed., I, pp. 750–771.

1907. Kellicott, W. E. Correlation and Variation in *B. l. americanus. Jour. Exper. Zool.,* IV, No. 4.

1901. King, H. D. The Maturation and Fertilization of the Egg of *B. lentiginosus. Jour. Morph.,* XVII, pp. 293–330.

1907. King, H. D. Food as a Factor in the Determination of Sex in Amphibians. *Bio. Bull. of Marine Bio. Lab.,* XIII, No. 1, pp. 40–56.

1904. Kirkland, A. H. The Habits, Food and Economic Value of the American Toad. Mass. Agri. College Bull., No. 40.

1882. Legrips, M. V. Vitality of Toads. *Knowledge,* I, p. 202. (This is probably Buckland's experiment and misquoted, as the same experiments are given with the same result. See ''Cosmos.'')

1904. Morse, M. Batrachians and Reptiles of Ohio. Bull. Ohio State Univ., Series 8, No. 18, pp. 96–123.

1871. Putnam, F. W. Some Statements concerning the Frogs and Toads found at Cambridge, Mass. *Proc. Bost. Soc. Nat. Hist.,* IX, pp. 229–230.

1888. Ryder, J. A.. ''Ventral Suckers'' or Sucking ''Disks'' of Tadpoles of different Genera of Frogs and Toads. AMER. NAT., XXII, p. 263.

1901. Sharp, D. L. Wild Life near Home, p. 313.

1905. Short, E. H. Editorials (on Skunks). *Oologist,* XXII, pp. 132–135. and 188–190.

1900. Slonaker, J. R. Some Observations on the Daily Habits of the Toad (*B. lentiginosus*). *Ind. Acad. Sci.,* pp. 167–170.

1906. Stone, W. Amphibians and Reptiles of New Jersey, Pennsylvania and Delaware. AMER. NAT., XL, pp. 159–170.

1863. Verrill, A. E. Catalogue of Reptiles and Batrachians found in the Vicinity of Norway, Maine. *Proc. Bost. Soc. Nat. Hist.,* IX, pp. 195–199.

1882. Yarrow, H. C. North American Reptiles and Batrachians. Bull. 24, U. S. Nat. Mus., pp. 166–167.